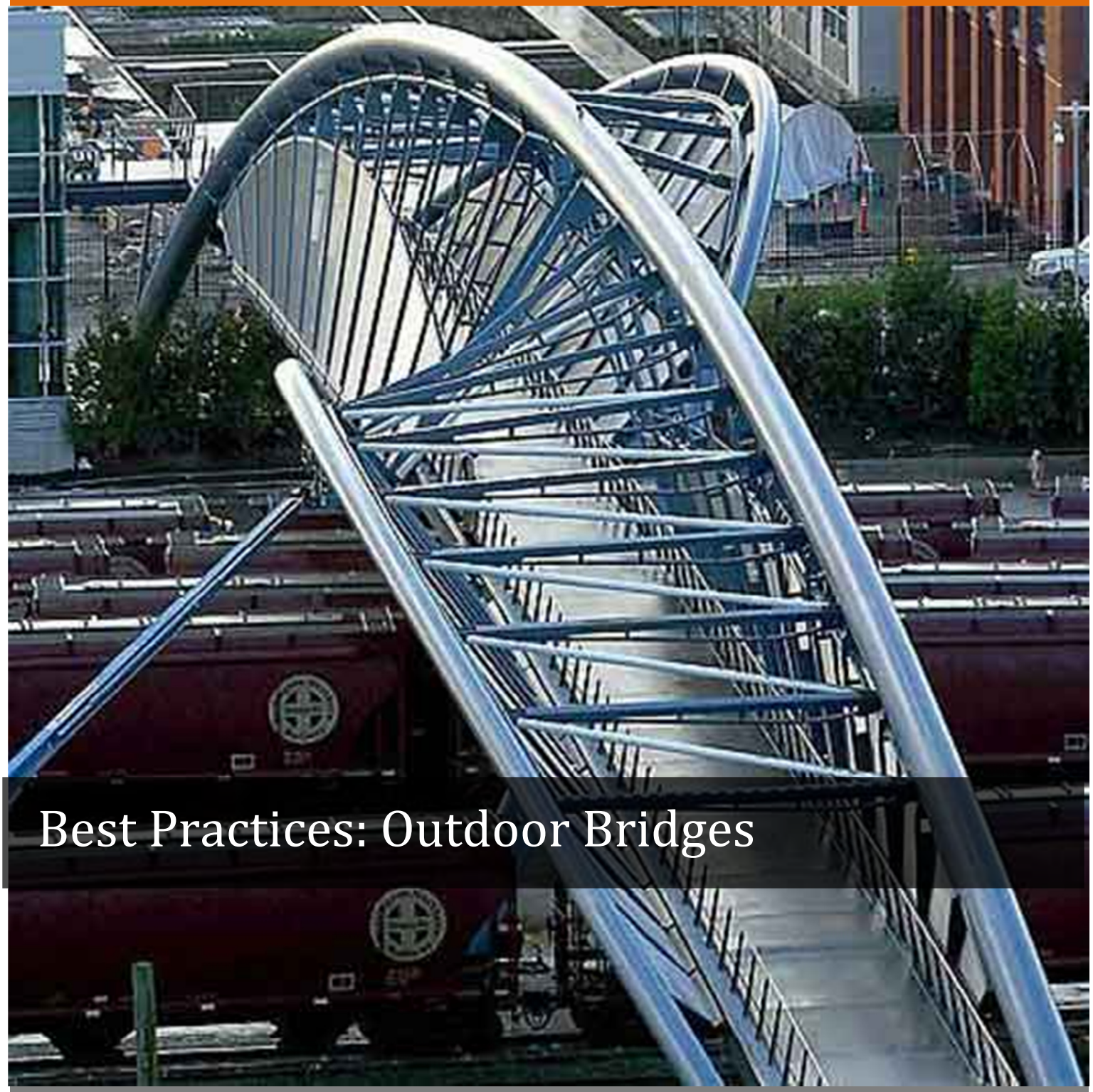

Best Practices: Outdoor Bridges

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OVERVIEW

In the world of networking, a wired network is invariably preferable to a wireless connection. But sometimes this isn't possible. Reasons can include a prohibitively high cost or simply not be physically possible.

A good alternative to a wired link is a wireless bridge. A wireless bridge connects two or more networks together. The bridge itself is transparent to Layer 2/3 traffic transmitted over the link; much as a fiber optic cable is transparent to transported data protocols.

All bridges consist of two or more units. The *root bridge* is the master device and should be located at the main network site. A *non-root bridge* is a unit that is paired or provisioned to work with the root bridge.

A bridge that consists of two units – a root and non –root bridge – is called a *point-to-point bridge*. The non-root bridge links a remote site back to the home network site where the root bridge is located.

Point-to-Multi-point bridges join multiple remote sites to the home network. Multiple non-root bridges connect to the root bridge.

BRIDGE VS. ACCESS POINT

A WiFi AP is designed to connect wireless clients to a network. Unlike a bridge, it does not connect one network to another network. Also, while an AP will typically accept a connection from any authorized wireless client; a bridge will only accept a connection from a unit that is provisioned as part of a matched bridge pair.

RUCKUS-SUPPORTED BRIDGES

The ZoneFlex 7731 is a high performance 5 GHz 802.11n bridge that supports point-to-point and point-to-multipoint links. It is ideal for long distance backhaul links. Like other Ruckus products, the 7731 features BeamFlex smart antenna array technology. If desired, external antennas may also be installed.

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SUPPORTED TOPOLOGIES

The 7731 is a flexible platform that accommodates a variety of configurations:

- Point-to-Point (PtP)
- Point-to-Multipoint (PtMP)
- Daisy chain linkage
- Parallel bridging

POINT-TO-POINT

The simplest bridge configuration is a single provisioned pair of 7731s. This is an excellent way to connect two locations. Depending on distance, up to 180 Mbps is achievable with the internal antennas alone.

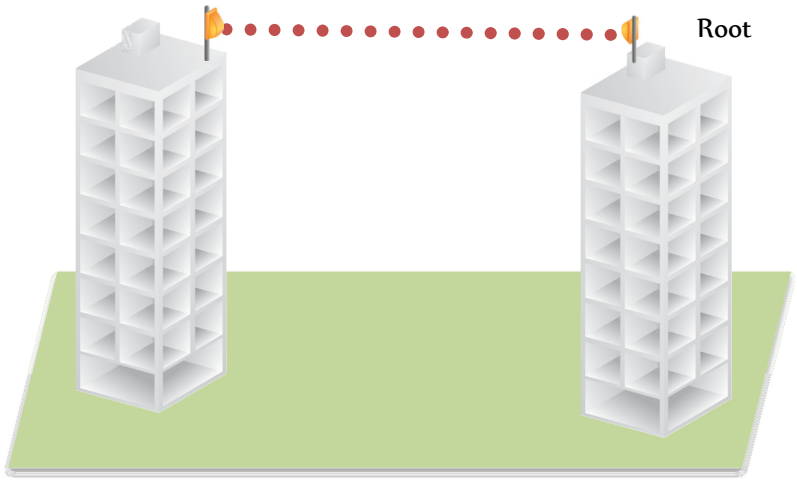

Figure 1: Point-to-Point Bridge Example

Example scenarios include: connecting two buildings, providing wireless backhaul, injecting (or preserving) bandwidth in a multi-hop mesh network.

Point-to-Point bridging requires a good signal between the root and non-root bridge. Maximum distance for a given link depends on the quality of the signal, external vs. internal antennas, Line of Sight (LOS), etc. With good operating parameters, a Point-to-Point bridge can go up to 20 km using the internal antennas alone.

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POINT-TO-MULTIPOINT

In a multipoint design, one root bridge supports multiple non-root bridge connections. This design is a good choice for connectivity between multiple remote sites to a single primary location.

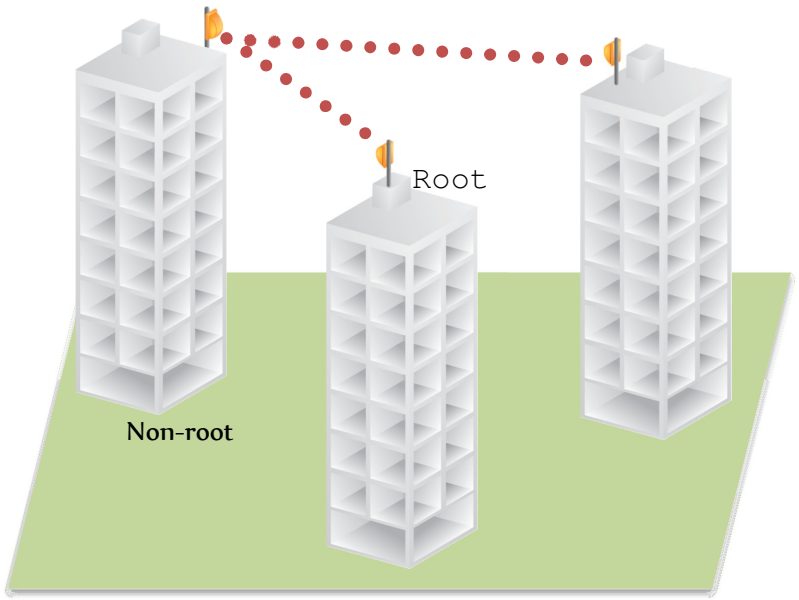

Figure 2: Point-to-Multipoint Example

In a Point-to-Multipoint configuration, there are many factors to consider. First, note that the maximum angle from the root bridge is 30 degrees using the internal antenna. The closer a non-root bridge is to the maximum value (30 degrees) from the root bridge, the more throughput performance decreases. If you go beyond 30 degrees, performance will be drastically impacted to the point that the connectivity may be lost entirely.

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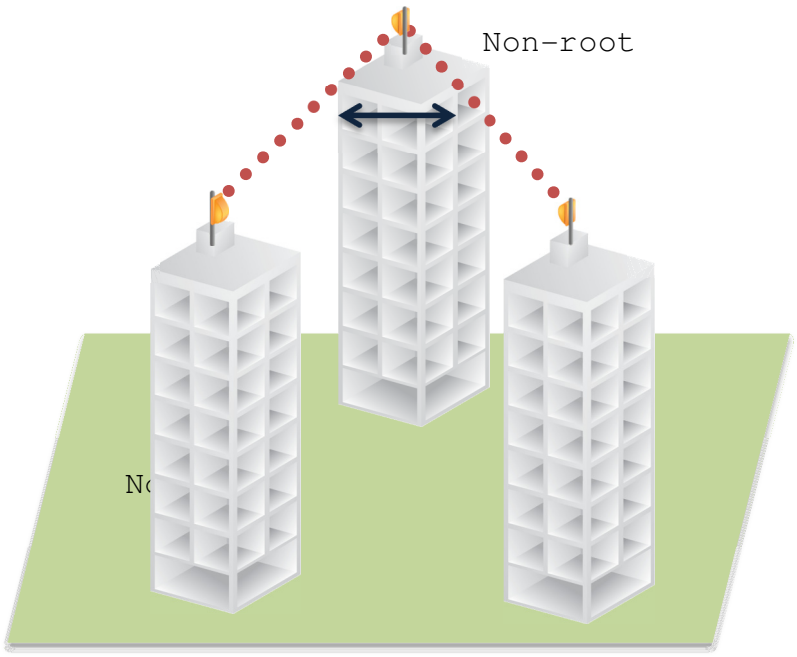

Figure 3: Beamwidth supported by internal antenna

That absolute distance has a significant impact on expected bridge performance is well know. Less well understood is the role of relative distances.

If one non-root bridge is at placed at the maximum distance from the root bridge (approximately 20 km), and the other is located very close, performance may be negatively impacted. This performance degradation is caused by large differences in the time delays on the two different transmission links.

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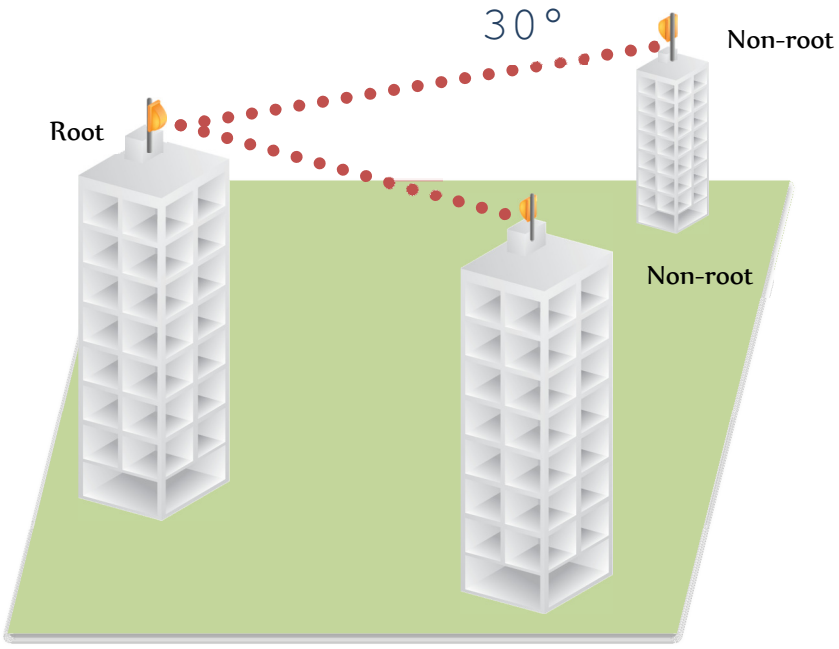

Figure 4: Asymmetric Point-to-Multipoint links

Point-to-Multipoint bridging requires all non-root bridges be able to maintain a good connection with the root. This can require a wider beamwidth than a simple PtP link. For more information on beamwidth and antenna selection, please refer to the section on antennas.

Daisy Chaining

Sometimes a single bridge cannot span the entire distance between two points. This could be due to a very long distance, or Non Line of Sight (Non LOS). A good solution to this problem is to chain bridge units back to back via their Ethernet ports.

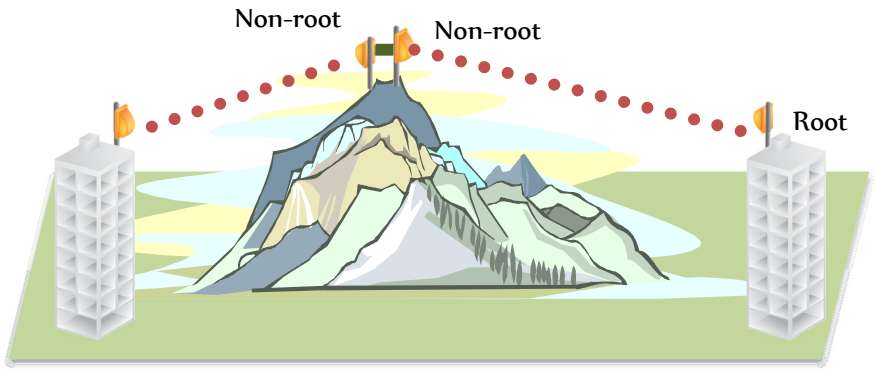

Figure 5: Bridge chaining example

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Daisy chaining is an excellent way to overcome obstacles that prevent a traditional bridge configuration. Care should be taken however, when mounting more than one 7731 on the same pole. Some physical separation (approximately 1 meter or more) is recommended to reduce any chance of interference between the adjacent units.

PARALLEL BRIDGING

Two or more pairs of bridges can be used to effectively double (or more) throughput between two locations.

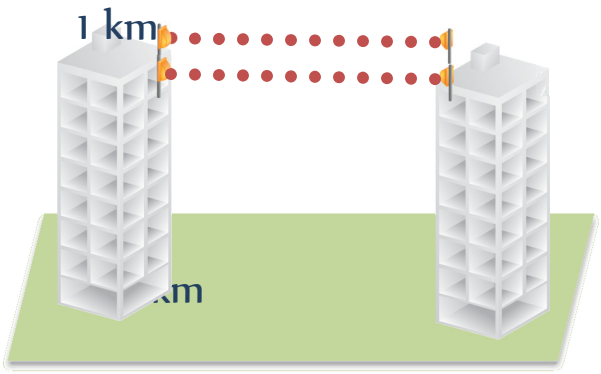

Figure 6: Parallel bridges example

Parallel bridging is an excellent way to increase throughput along the same physical route. Care should be taken however, when mounting more than one 7731 on the same pole. Some physical separation (approximately 1 meter or more) is recommended to reduce any chance of interference between the adjacent units.

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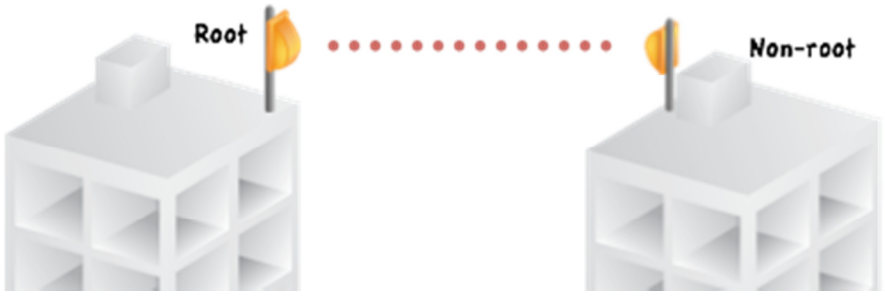
MOUNTING & AIMING

ORIENTATION

The recommended mounting of the 7731 should always be vertical with both units facing each other (dome in front). No other mounting configuration is supported.



LINE OF SIGHT (LOS)

Each bridge unit should have a direct Line of Sight (LOS) with the other. Wherever possible, the LOS should be clear of obstructions. In particular, pay close attention to potential obstructions that may fluctuate such as trees, which are green part of the year and bare the rest of the year.

Another common cause of signal fluctuation is pole sway. This occurs when one or more of the units are mounted on a pole with significant sway. Mounting locations should be solidly attached in a fixed position at all times.

PROXIMITY RF INTERFERENCE

If a 7731 unit is mounted in proximity to another 7731 bridge or other source of RF interference, at least 1 meter of separation should be maintained. A good separation helps prevent unnecessary interference with bridge operation.

INITIAL AIMING

Each 7731 unit features an exterior aiming button. Pushing this starts an aiming cycle. During this cycle the unit attempts to contact its paired unit. The LEDs on the back of the unit indicate the strength of the received signal: LED 6 (maximum signal) to LED1 (minimum operational signal) to flashing yellow (no signal/association).

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Since the bridge operates completely transparently to IP traffic, the units do not need to be assigned IP addresses or configured via the user interface. However some additional information is available through the Web UI of the units. For example, the UI features supplementary information such as the RSSI ACK value. Using this value provides a more precise tool for aiming. The better the bridge units are aligned, the better overall performance will be.

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CHANNEL OPTIMIZATION

INITIAL CHANNEL SELECTION

When a pair of 7731s is first booted, the units select an initial channel to transmit.[1] Once the units are aimed properly, you should use the channel optimizer option on the Web UI to enable *SmartSelect*. SmartSelect performs a scan of all available channels to determine the optimal channel.

SmartSelect channel optimization occurs after the initial aiming and bridge setup. The root bridge automatically initiates a channel scan to determine the optimal channel for the current environment. Channel section takes into consideration the current Signal to Noise Ratio (SNR) for each channel and maximum allowed power,

Once it has scanned each channel and made a selection, the root bridge sends a message to all non-root bridges informing them of the proper channel to use.

POST-INSTALL OPTIMIZATION

You can also manually initiate this channel scan process at any time. Ruckus Wireless recommends manually running the channel optimizer again each time additional non-root bridges are added (after the aiming process is complete). This allows the bridges to accommodate any RF interference at the new non-root bridge that would prevent optimal performance.

Whenever possible, Ruckus Wireless recommends using the highest numbered channel available, this is generally also the channel with the greatest transmit power as well. If one of these channels is not available, the next best channel should be selected.

If performance is still poor after channel optimization and power adjustment, this may be due to nearby RF interference or positioning; in first case, check for a different channel. In the second case, try to re-aim the units.

If none of these procedures works, a change of location for one or more of the units may be required.

[1] In the US, this is typically channel 157.

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CHANNEL WIDTH

A 20 MHz channel width does not provide the same potential throughput as a wider, "bonded" channel. Whenever possible, a 40 MHz channel width should be used. This is a requirement to achieve the highest possible throughput.

Channel Width	Available Data Rates (802.11an)
20 MHz	6.5 Mbps – 130 Mbps
40 MHz	6.5 Mbps – 270 Mbps

CHANNEL WIDTH AND BRIDGE DISTANCE

One limiting factor is the distance between bridge units. A 40 MHz wide channel has a maximum distance of 27 kilometers. Bridge links longer than this may need to use a 20 MHz channel instead. 20 MHz wide channels have a maximum distance of 57 kilometers.

Long distance shots will also require a large ACK timeout value. The ACK timeout is the maximum amount of time a unit while wait the other end to acknowledge receipt of a packet. If the bridge does not receive a response within the ACK timeout value, it will assume packet loss and resend.

The longer the distance between bridge units, the longer it will take for an acknowledgement. Constant timeouts and retransmission will greatly affect bridge performance and overall throughput.

The timeout is adjusted on the 7731 using the CLI. The value is set using the intended bridge distance. If a large number of retransmits are still occurring, it is acceptable to increase the timeout value. In general, it is always preferable to err with a larger value rather than one that is too small.

```
set distance wifi0 20000
```

The ACK timeout value must be configured the same for **both** bridge units.

ACKNOWLEDGEMENTS IN A PTMP ENVIRONMENT

When more than one non-bridge unit is deployed, special care must be taken to ensure both are within roughly the same distance.

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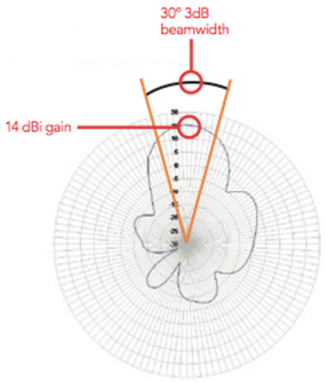
EXTERNAL ANTENNAS

The internal BeamFlex adaptive antenna array supports a 30° 3 dB beamwidth and a maximum gain of 14 dBi. However, some applications may require external antennas. Examples of this include:



- Distances longer than 20 km
- Higher required throughput
- Larger beamwidth
- Smaller beamwidth

SIGNAL GAIN

An increase in signal gain can provide connectivity at longer link distances for the bridge. Likewise, a higher gain can translate to higher throughput as opposed to the internal antenna where the external antenna gain is greater than 14 dBi.

When choosing an external antenna, ensure it complies with all local regulatory requirements and does not exceed maximum allowed transmit power/EIRP.

BEAMWIDTH

A different antenna beamwidth may be required if:

- A higher gain antenna is used (higher gain typically reduces beamwidth)
- The environment has too much RF noise: choose a narrower beamwidth to exclude adjacent or nearby noise
- A Point-to-Multipoint configuration requires a larger beamwidth to accommodate all remote non-root bridges

ANTENNA HARDWARE

Ruckus Wireless recommends the following antennas:

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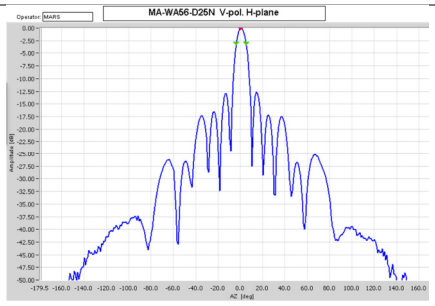
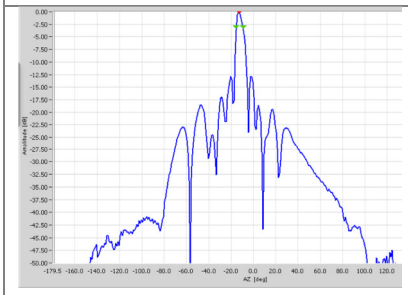
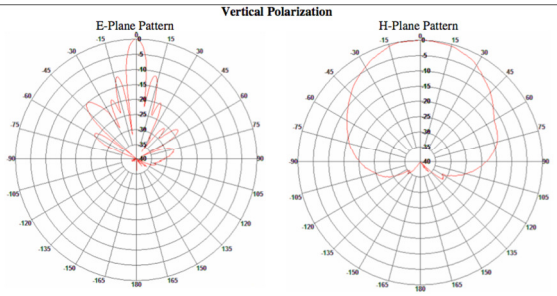
Mars 4.9-5.875 GHz Dual Polarized/Dual Slant Antenna & Enclosure (Part number: MA-WA56-DP25SBRF) 	 
Mars 4.9-6.1 GHz Dual Polarized Base Station Antenna, 90° (Part number: MA-WC56-DP16)	
Mars 4.9-6.1 GHz Dual Slant Base Station Antenna, 60º (Part number: MA-WC55-DS17)	

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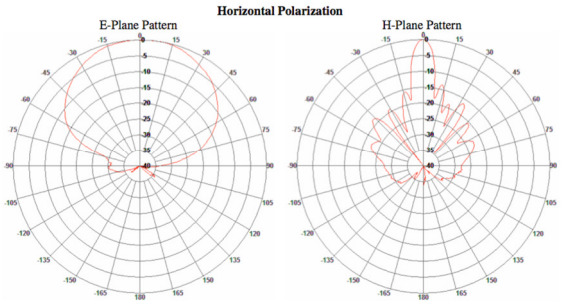
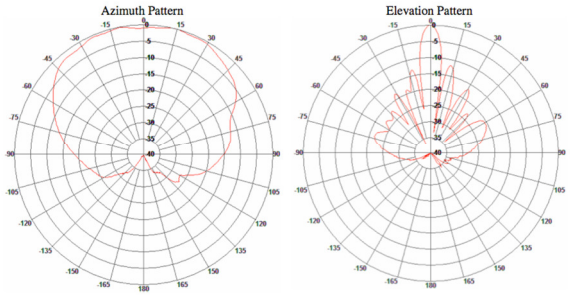


Mars 4.9-6.1 GHz Dual Slant Base Station Antenna, 90° (Part number: MA-WD55-DS16)



HyperGain 5.1 GHz to 5.8 GHz 28.5 dBi Broadband Parabolic Dish Antenna

(Part number: HG5158DP-29D)

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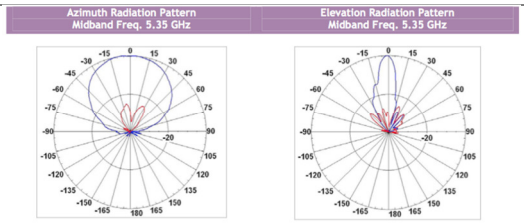
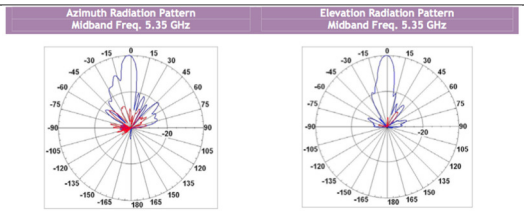
MTI 5.15-5.875GHz 16dBi 60deg Dual Pol. Null Filled Base Station Antenna (Part number: MT-484026/NVH) 	

MTI 5.25-5.875GHz 14dBi 90deg Dual Pol. Null Filled Base Station Antenna (Part number: MT-484027/NVH) 	

In addition to the antenna, each 7731 will also require two N-male/N-male RF cables (~50cm).

Other external antennas may also be used, just ensure they have N-type connectors and are dual-polarized.

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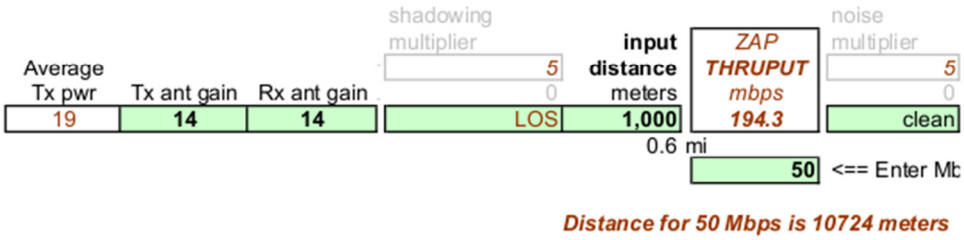
THROUGHPUT PLANNING

Ruckus Wireless offers a planning tool to aid in capacity planning. This tool is s spreadsheet that is available at http://partners.ruckuswireless.com/XXXX.



The tool offers two tabs: one for calculating performance with a 40 MHz wide channel and the second for a 20 MHz channel. The spreadsheet allows modification of the following inputs:

Average transmit power – Average power in dBm

Transmit antenna gain - Tx antenna gain

Receive antenna gain – Rx antenna gain

Line of Sight (LOS) – Line of Sight (no obstructions), Shadowed LOS (some obstruction), Non LOS (no visual line of sight)

Shadowing factor – amount of shadowing, in percentage

Distance / throughput – distance of the link or desired throughput

Noise multiplier – a value indicating noise level in the link path and nearby

The calculator estimates either link distance (given a desired throughput) or expected throughput given a specific distance.

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